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Thermoluminescence Investigations of Tl2Ga2Se3S Layered Single Crystals

Authors : Serdar Delice, Mehmet Isik, Nizami Hasanli, Kadir Goksen

Abstract : Researchers have donated great interest to ternary and quaternary semiconductor compounds especially with the improvement of the optoelectronic technology. The quaternary compound Tl2Ga2Se3S which was grown by Bridgman method carries the properties of ternary thallium chalcogenides group of semiconductors with layered structure. This compound can be formed from TlGaSe2 crystals replacing the one quarter of selenium atom by sulfur atom. Although Tl2Ga2Se3S crystals are not intentionally doped, some unintended defect types such as point defects, dislocations and stacking faults can occur during growth processes of crystals. These defects can cause undesirable problems in semiconductor materials especially produced for optoelectronic technology. Defects of various types in the semiconductor devices like LEDs and field effect transistor may act as a non-radiative or scattering center in electron transport. Also, quick recombination of holes with electrons without any energy transfer between charge carriers can occur due to the existence of defects. Therefore, the characterization of defects may help the researchers working in this field to produce high quality devices. Thermoluminescence (TL) is an effective experimental method to determine the kinetic parameters of trap centers due to defects in crystals. In this method, the sample is illuminated at low temperature by a light whose energy is bigger than the band gap of studied sample. Thus, charge carriers in the valence band are excited to delocalized band. Then, the charge carriers excited into conduction band are trapped. The trapped charge carriers are released by heating the sample gradually and these carriers then recombine with the opposite carriers at the recombination center. By this way, some luminescence is emitted from the samples. The emitted luminescence is converted to pulses by using an experimental setup controlled by computer program and TL spectrum is obtained. Defect characterization of Tl2Ga2Se3S single crystals has been performed by TL measurements at low temperatures between 10 and 300 K with various heating rate ranging from 0.6 to 1.0 K/s. The TL signal due to the luminescence from trap centers revealed one glow peak having maximum temperature of 36 K. Curve fitting and various heating rate methods were used for the analysis of the glow curve. The activation energy of 13 meV was found by the application of curve fitting method. This practical method established also that the trap center exhibits the characteristics of mixed (general) kinetic order. In addition, various heating rate analysis gave a compatible result (13 meV) with curve fitting as the temperature lag effect was taken into consideration. Since the studied crystals were not intentionally doped, these centers are thought to originate from stacking faults, which are quite possible in Tl2Ga2Se3S due to the weakness of the van der Waals forces between the layers. Distribution of traps was also investigated using an experimental method. A quasi-continuous distribution was attributed to the determined trap centers.

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